

Enhancing Chinese Percussion Education through Virtual Reality: Psychological Impact and Academic Performance

Aprimorando o Ensino de Percussão Chinesa por meio da Realidade Virtual: Impacto Psicológico e Desempenho Acadêmico



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Abstract: Music education has long played a vital role in cultural development, and new technologies now enable innovative approaches to enhance its effectiveness. This study examines the psychological impact and academic outcomes of employing virtual reality (VR) technologies in teaching Chinese percussion instruments. Research methods included analysis, experimental implementation, and testing. Results indicate that the bangu and paigu are the most suitable drums for percussive performance, with bangu achieving a higher psychological impact in Xu Changjun's Sword Dance (45.8 points) compared to paigu (42.5 points). Data further revealed substantial improvements when VR technologies were integrated into instruction, with increases in technical skills (30%), music theory knowledge (28.6%), and musical interpretation (29.4%). Moreover, VR enhanced psychological engagement by 41.7% relative to traditional training. These findings suggest that innovative technologies not only improve practical and theoretical outcomes but also foster deeper psychological involvement in the learning process. The research underscores the value of integrating VR into music education, highlighting its potential to enrich both performance and comprehension. Ultimately, the introduction of such methods can enhance the quality of instruction in music

schools and universities, supporting the development of more effective educational programs.

Keywords: percussion instruments. consonance of elements. music perception. harmony. virtual reality.

Resumo: A educação musical sempre desempenhou um papel fundamental no desenvolvimento cultural, e as novas tecnologias agora possibilitam abordagens inovadoras para aumentar sua eficácia. Este estudo examina o impacto psicológico e os resultados acadêmicos do uso de tecnologias de realidade virtual (RV) no ensino de instrumentos de percussão chineses. Os métodos de pesquisa incluíram análise, implementação experimental e testes. Os resultados indicam que o bangu e o paigu são os tambores mais adequados para a performance percussiva, sendo que o bangu obteve maior impacto psicológico na Dança da Espada de Xu Changjun (45,8 pontos) em comparação ao paigu (42,5 pontos). Os dados também revelaram melhorias significativas quando as tecnologias de RV foram integradas ao ensino, com aumentos de 30% nas habilidades técnicas, de 28,6% no conhecimento de teoria musical e de 29,4% na interpretação musical. Além disso, a RV aumentou o engajamento psicológico em 41,7% em relação ao treinamento tradicional. Esses achados sugerem que as tecnologias inovadoras não apenas melhoram os resultados práticos e teóricos, mas também promovem um envolvimento psicológico mais profundo no processo de aprendizagem. A pesquisa destaca o valor da integração da RV à educação musical, evidenciando seu potencial para enriquecer tanto a performance quanto a compreensão. Em última análise, a adoção de tais métodos pode elevar a qualidade do ensino em escolas e universidades de música, apoiando o desenvolvimento de programas educacionais mais eficazes.

Palavras-chave: instrumentos de percussão. consonância de elementos. percepção musical. harmonia. realidade virtual.

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1. Introduction

1.1 Percussion in Traditional World Music

Percussion instruments play an essential role in the traditional music of different cultures, contributing to both rhythmic structure and expressive aesthetics (Korošec, 2025). By examining various percussion traditions worldwide, we can see how these instruments serve not only as musical instruments but also as cultural symbols and modes of communication. Below is an analysis of scholarly articles that discuss the features of playing different percussion instruments and the aesthetics they create.

African drumming is used to convey linguistic features, such as messages, the emotionality of speech, and so forth. To this end, musicians employ different variations of rhythms using the drum language Sabar. Established phrases, as well as improvised ones, are often utilized in this drum language. It has been established that drum beats can be associated with a variety of vowels (front, central, open, and closed) (Ros, 2021). Drumming in puppet theaters in India (marionette theaters or leather puppets) has preserved cultural traditions and religious practices since ancient times. These rhythmic sounds contribute to the dramatic storytelling process, enhancing both the narrative and emotional impact on audiences. The use of percussion in such settings illustrates its role in theatrical and religious traditions.

Rhythmic sounds, defined by changes in pitch, shape, and repetition, influence listeners' interest in musical compositions. A recent study has analyzed high-frequency and low-frequency sounds. According to the findings, listeners prefer bass melodies that retain low-frequency energy and timbre (Lustig and Tan, 2020). When using drum sounds in musical compositions, attention should be paid to their synchronicity with the musical instruments. The harmony of the sound depends on the strength

of the beat, which affects the reproduction of sounds of different amplitudes. Beat variations affect the melodic sound of musical compositions (Parlikar and Jagannath, 2021). Through these studies, we see that percussion is not only a rhythmic backbone but also a significant driver of musical aesthetics and emotional impact.

Music seeks to evoke emotions such as joy, anxiety, happiness, and sadness in listeners, serving as an element of expression for performers and composers. Percussion instruments, through their ability to manipulate rhythm and tone, significantly enhance the expressiveness of musical works worldwide. The rhythmic sounds of percussion instruments contribute to the saturation of musical compositions and to changes in vibrations (Ismail et al., 2021). The study of percussion across cultures reveals its significance in reinforcing musical traditions, enhancing expressive depth, and connecting performers with audiences. This exploration of world percussion traditions provides valuable insights into how rhythm and drumming continue to shape musical expression across diverse cultural landscapes.

1.2 Percussion in Chinese Music

The uniqueness of Chinese compositions stems from the use of strings, keyboard, plucked strings, percussion, and wind instruments (Buathong and Binson, 2020). Among these, percussion instruments hold a special place due to their historical and cultural significance. The value of musical instruments is evident in folk songs that imitate the singing of birds or the sound of running water. These songs preserve pentatonic, colorful, and vivid sounds (Hamzah and Baharuddin, 2020). Percussion instruments (shugu, gong, bianqing, etc.) are among the most ancient traditional musical instruments, a special category being the Chinese drums (Faraco, 2021; Wang et al., 2021). The preservation of folk traditions through Chinese percussion instruments contributes to the complexity

of their use by Western musicians. The main challenges include timbral features, the imitation of natural sounds, and social phenomena (Huang et al., 2025; Qi et al., 2020). Understanding these challenges highlights the depth of Chinese percussion music and its impact on global musical traditions.

The large variety of drum sounds in Chinese music (tian, zan, dongdong, dangda) allows for harmony in Chinese music and creates a unique style of performance (Legendre and Varela, 2020; Marshall and Shibazaki, 2013). For example, in ancient times, percussion instruments (drums) served not only for the aesthetic sound in the orchestra but also for announcing the arrival of important people (Legendre and Varela, 2020). Due to the vast number of drum types, a plethora of different sounds can be produced. These diverse applications illustrate the significant role that percussion instruments play in shaping the structure and rhythm of Chinese music.

In house and techno music, special attention is paid to the importance of vibration, timbre, and granular synthesis. These elements are aimed at resonating the power of impact and aesthetics of sound reproduction (Garcia, 2015). Italian ethnic musical percussion instruments add vibroacoustic elements (sounds, vibration, and intonation). The harmony of sounds is achieved at a certain pitch where the notes are tuned. Percussion music is used both in theatrical acts and academic works to strengthen the power of sound (Tronchin et al., 2020). Drawing parallels between Chinese and Western music deepens understanding of how percussion instruments contribute to musical expression across cultures.

Between 453 and 221 B.C., Chinese percussion instruments (drums and bells) were utilized to communicate military actions. The sound of percussion instruments went beyond the aesthetic purpose of military music, emphasizing the importance of organized action (Rom, 2020). The musical culture of the Chinese Miao people is associated with special acoustic sounds of melodies performed at festivals and ritual

performances. Bronze drums shaped the acoustics of their sounds. The clapping of hands at five different points formed the impulsive sound and represented the sounds produced by the bronze drums (Mao and Liu, 2018). Thus, percussion instruments in China have served not only a musical function but also a communicative and cultural one, deeply intertwined with historical traditions.

Chinese drums are particularly important in traditional music because they help convey the necessary rhythm that enhances the culmination of a piece (Liu, 2019; Matthews et al., 2018). Drums contribute to a variety of rhythms that aim to create distinctive musical compositions (Hanson, 2019). When composing music with drums, it is important to maintain trichord and pentatonic harmonies, as well as intonation between sounds, to create textured chords, rhythmic formulas, and a logical construction of compositions (Friedl, 2017; Jiang and Sun, 2021). This rhythmic complexity reflects the sophistication of Chinese musical traditions and their emphasis on harmony and structure.

Percussion instruments are also important for Beijing opera. The established rhythms create the atmosphere of the staged action and maintain the timbre of the storyline (Jose et al., 2018). Rhythm shapes the expressiveness of compositions, creating a special harmony and beauty and unveiling the meaning of a composition (Chao, 2020). Percussion instruments considerably enrich the form and content of musical performances (Fridman, 2015). In China, percussion instruments also serve as a link between traditional and folk music, made possible by the expressive power of drums (Chang, 2021).

1.3 Music Psychology and Percussion

Music psychology is a scientific discipline that examines the influence of music on the human psyche, emotions, and behavior (Hargreaves, 2023). Percussion instruments, with their strong rhythmic nature, play a fundamental role in music

psychology, influencing cognitive and emotional responses. This field combines knowledge from psychology, musicology, neuroscience, and cognitive sciences to explore how people perceive, interpret, and respond to music (Pozo, 2022). Percussion, which is primarily rhythmic and perhaps the most ancient form of music, alongside singing, is extremely important for music psychology (Van Kerrebroeck et al., 2021; Werner et al., 2015). This suggests that rhythm and drumming have long been essential in human communication, ritual, and emotional expression.

Since ancient times, drums have been used in ritual dances, ceremonies, and military actions. Drumming helps to convey the moods of the characters, their activities, and changes in nature, thereby creating a special psychological impact on performances (Stoliarova, 2020). The popularization of percussion instruments has led to the emergence of more sophisticated playing techniques that go beyond the sonic capabilities of drums. Additional rings have been added to the outer membranes to increase the power of the drums and alter the rhythmic nature of the sounds produced when struck (Bader et al., 2019).

Drumming enhances the emotional and psychological aspects of singing by displaying harmonic sounds. The timing of beats, chords, and vocals is combined with the musical sounds that are the foundation of music. The incorporation of drums into a musical composition necessitates assessing the overall composition to harmonize percussive sounds (Dobashi et al., 2015). By examining these elements, we gain deeper insights into how percussion affects human perception and emotional responses (Bhatti et al., 2016). One of the primary applications of music psychology in percussion training lies in the development of rhythmic perception, motor coordination, and the performer's emotional expressiveness. The unique nature of Chinese percussion instruments enables the implementation of specialized methodologies that integrate traditional

performance techniques with contemporary knowledge of cognitive rhythm perception. For instance, instruction through repetitive rhythmic patterns fosters the formation of neural connections that enhance concentration and responsiveness to musical stimuli. Traditional Chinese music often incorporates diverse rhythmic structures and complex rhythmic patterns, which demand a high level of auditory discrimination and cognitive flexibility from learners. Visualization of rhythms or tactile feedback via vibration can assist students in mastering intricate Chinese rhythmic techniques, thereby facilitating the integration of these patterns into their performance practice.

1.4 Music Education and Virtual Reality

In recent years, music education research has increasingly focused on integrating technology into the learning process. As the digital age progresses, new technologies are being explored to enhance the teaching and learning of music. Many authors from all over the world explore the impact of innovative technologies on music learning (Olvera-Fernández et al., 2023). Chinese traditional percussion instruments, such as drums, have a long history and hold a special place in China's cultural heritage. However, the challenge remains: integrating these traditional instruments into modern educational frameworks while preserving their authenticity.

One of the main challenges is adapting teaching methods to the needs of today's students, who increasingly use technology in their daily lives. Innovative technologies, including virtual reality (VR) and artificial intelligence (AI), can be the key to solving this problem (Hernandez-Ruiz, 2025). The use of these technologies in the educational process opens new opportunities to attract students and improve learning efficiency. A virtual percussion instrument, Hyper Drumhead, has been developed for this

purpose. To preserve authentic sounds, wave propagation is simulated in real time using a virtual percussion instrument. This innovation not only maintains the integrity of traditional sounds but also expands creative possibilities in music education.

Virtual reality creates immersive learning environments where students can interact with virtual tools and receive real-time feedback (Degli Innocenti et al., 2019). Despite its potential, VR in music education is still in the early stages of implementation. Some researchers emphasize its benefits, particularly in psychological and technical preparation for live performances (Osborne et al., 2022; Ppali et al., 2022). Others highlight its ability to enhance creativity and refine technical skills (Jing, 2022; Rutkowski et al., 2021). While VR applications are becoming more common in practice, research on their impact on traditional music education remains limited, pointing to an important area for future exploration.

1.5 The Impact of Virtual Reality on the Psychological State of Students

Studies investigating the impact of virtual reality (VR) technology on the psychological and emotional states of music education students have revealed multidimensional cognitive and emotional changes resulting from integrating VR into the learning process. VR-based education has been shown to enhance the acquisition of musical material by increasing cognitive engagement, reducing performance-related anxiety, and accelerating the development of sensorimotor learning mechanisms (Bellinger et al., 2023; Yang et al., 2024; Yu et al., 2023). Virtual reality tools have reshaped the process of acquiring musical skills by manipulating the perception of spatial and acoustic properties of the auditory environment. Their capacity to simulate real concert settings has enabled students to better adapt to stressors typically associated with traditional methods of music education (Park et al., 2023).

Immersion in virtual environments has been found to facilitate desensitization to performance anxiety, as evidenced by a decrease in psychophysiological stress markers such as heart rate and cortisol levels (Bellinger et al., 2023). Simulations that allow real-time adjustments to tempo, volume, and timbre activate emotional self-regulation mechanisms essential for developing musical interpretation (D'Errico et al., 2023). Furthermore, virtual reality has been shown to foster metacognitive strategies of musical thinking, including reflective self-analysis and the refinement of both technical and artistic aspects of performance (Pesek et al., 2024).

In addition to these positive outcomes, some studies have highlighted the risk of cognitive overload due to excessive use of virtual reality tools (Graham et al., 2023; Sari et al., 2024). Intense sensory stimulation may lead to disorientation, and prolonged exposure to virtual environments can result in dizziness, potentially hindering the learning process (Conner et al., 2022).

1.6 Study's Motivation, Contribution, and Objectives

The motivation for the present study is the need to examine the impact of innovative technologies on music instruction, particularly on the use of Chinese traditional percussion instruments. This topic is relevant since the combination of traditional musical instruments with modern technologies can help preserve cultural heritage while adapting it to modern educational requirements. The scientific novelty of the study lies in new data on the psychological impact of innovative technologies on learning to play Chinese traditional percussion instruments. This research can significantly contribute to the development of music pedagogy and new teaching methods that combine tradition and innovation. The instruments studied in this experiment, the bangu and paigu, are both classified as percussion instruments that produce harmonious sounds. These instruments play an important role in creating musical

compositions' emotional and psychological impact, such as Xu Changjun's composition ("Sword Dance"). "Sword Dance" is the reference work for this study because it represents the characteristics of traditional Chinese music well and has a rich rhythmic structure. This composition is characterized by complex rhythmic patterns, which not only ensure the repetition and harmony of musical elements but also contribute to its emotional and dramatic expression. By studying "Sword Dance," it is possible to explore the technical and interpretative aspects of rhythmic performance, as well as assess the psychological impact of incorporating dynamic rhythms within a traditional musical framework on both performers and listeners.

Each percussion instrument possesses unique acoustic characteristics that influence emotional perception, cognitive responses, and the listener's physiological state. Therefore, understanding the specific properties of a musical instrument is essential for developing accurate virtual models for instructional purposes, as it ensures an authentic experience and appropriate emotional engagement for students. Rhythm plays a crucial role in shaping the psychological and emotional impact of music, and the selection of a particular drum determines the timbral qualities of the sound, which in turn affects perceptual processing and the level of emotional involvement of the learner. Recreating this dynamic interaction in a virtual reality environment requires realistic auditory rendering to facilitate immersive learning and to optimize students' engagement with rhythm and movement. Thus, the study aims to examine the impact of innovative teaching methods (VR) on the level of academic anxiety among students learning Chinese percussion instruments.

2. Methodology

2.1 Participants

The study involved 108 participants, all students in the music education program. Participants were selected using targeted sampling to include those with experience or interest in learning Chinese percussion instruments. The participants were undergraduate students in their first through third years of study. Inclusion criteria for participation included experience playing percussion instruments or interest in learning Chinese percussion, a desire to adopt innovative teaching methods, including virtual reality (VR), and willingness to participate in the research. Exclusion criteria: individuals with physical or mental disabilities that prevented them from participating in VR training, and those who lacked the necessary technical skills for research. The average age of the participants was 21.4 years. There were 64 females and 44 males. Students were invited to participate in the study through advertisements at educational institutions. These advertisements included posters, emails, and direct communication during music classes. Interested individuals were provided with additional information about the study and asked to sign a consent form before participating.

The study participants were Chinese and non-Chinese students (66 and 42 non-Chinese). Experience playing non-traditional Chinese instruments made learning Chinese instruments much easier. This sampling approach enabled a comparative analysis of the learning trajectories of musicians from diverse ethnic and cultural backgrounds. It allowed for the identification of potential influences of culturally specific rhythmic cognitive patterns on the effectiveness of acquiring Chinese rhythmic structures. To mitigate the impact of cultural differences and prevent their confounding effects on research outcomes, several control strategies were

implemented: participant groups were balanced with respect to prior performance experience; instructional materials and pedagogical approaches were standardized to ensure consistent exposure to learning stimuli across experimental groups.

2.2 Research Design

Initially, the study was conducted to identify some of the most popular drums in China. The analysis method was employed at this stage in order to study various literary sources (presented in the first part of the paper), as well as to identify the most significant elements that distinguish the drums from each other (Leach, 2019). This method also allowed for structuring information, including data on the design of drums, the manufacture of materials, practical applications, and sonic features. The analysis revealed that the most common types of drums are bajiao gu, bangu, bianqing, tanggu, diangu, and paigu. Based on the findings, the goal of the second stage of the study was to select, according to the characteristics provided earlier, the two drums that would be more harmonious in Xu Changjun's "Sword Dance" composition. This composition was chosen for the study because it conveys traditional features and includes rhythmic figures that provide repeated musical elements.

At the third stage, the study determined the psychological elements of musical performance using innovative technological percussion instruments. The selected psychological elements were harmony, emotionality, traditionalism, consonance of sounds, smoothness of sound transitions, sonority, and average harmony score. In this study, the innovative training program for students focused on Chinese percussion instruments. The program included several stages that provided a comprehensive approach to developing musical skills. The main goal was to integrate modern technologies, such as virtual reality (VR), to improve the learning process and increase student learning efficiency. Paradiddle, an application for practicing music, was

used to learn to play the drums. The application offers the following range of features: a rhythmic game mode that allows users to create their songs; 25 different types of percussion instruments, including drums, keyboard percussion instruments (xylophone, marimba, and glockenspiel), as well as bongos, tambourines, and timpani; a realistic and sensitive sound system; the opportunity to save and download different kits and record sessions; USB and Bluetooth support for controlling drums and hi-hats using pedals; and the opportunity to import any song or audio file into the Quest file system (Figure 1).

Figure 1 - Experimental Process in a Music Classroom



The application includes virtual lessons, song performance simulations, and interactive exercises. Students can practice in virtual classrooms, perform virtual concerts, and interact with virtual instructors. The platform provides an opportunity to learn at an individual pace, choose the level of difficulty, and receive personalized tasks. The study also used performance analysis software, such as SmartMusic and Soundtrap. These programs include features for recording, analyzing, and evaluating students' performance. The applications provide real-time feedback, highlight problems, and offer suggestions for improvement.

Moreover, careful measures were taken to ensure that the instructional modules delivered to both groups encompass identical technical, theoretical, and interpretative components. The control group was assembled according to the principle of ethnocultural symmetry: the number of non-Chinese participants matched the corresponding demographic in the experimental group. This stratified sampling approach minimized the potential influence of latent variables, such as cultural distance from Chinese musical traditions, thereby mitigating bias arising from cultural heterogeneity among respondents. This methodological step enhanced the validity of the comparative analysis, ensuring that the observed learning outcomes associated with the use of VR technologies reflected the effectiveness of the instructional approach itself rather than being artifacts of intercultural variation.

Participants in the experimental group were provided with VR headsets equipped with hand-held controllers and connected devices, specifically the PlayStation VR2. Before the commencement of the study, a general setup of the participants' devices was conducted to ensure high-quality access to all necessary application features. The control group received instruction through traditional means, utilizing authentic percussion instruments during in-person sessions with real instructors. Both groups engaged in 10 hours of instruction per week, with the training lasting one academic semester.

The content of instruction was standardized and developed in accordance with an approved curriculum, identical in structure and volume to the version adapted for VR, thereby ensuring equivalence in instructional content across both experimental conditions. The control group's instruction adhered strictly to the classical paradigm of face-to-face learning in a classroom setting, employing traditional pedagogical strategies such as direct interaction with the instructor, demonstrative performance, and repetition-based methods. Instruction was delivered in real time by certified experts in Chinese percussion instruments within a physical training studio.

2.3 Evaluation

The evaluation was conducted by an independent panel of six experts specializing in traditional Chinese music and performance, each with at least 10 years of experience playing Chinese percussion instruments. Three of the evaluators held doctoral degrees in musicology. Before the assessment, all experts underwent calibration training to standardize their evaluative approach and minimize subjective bias. Each participant performed a standardized rhythmic composition, and the expert panel analyzed the recordings. Scores were assigned individually by each evaluator and then averaged using a blind-review method, in which the experts were unaware of the performers' identities to eliminate potential evaluator bias.

1) *Technical skills*: The ability to perform technically complex exercises using the drums. Each student had to demonstrate various performance techniques, such as strokes of different strength and speed, rhythmic patterns, and other technical elements. The assessment criteria included accuracy, speed, coordination of movements, and overall performance quality.

2) *Knowledge of music theory*. The test consisted of questions about notes, rhythms, chords, composition structures, and musical terms. The tasks were designed to assess students' understanding of basic and advanced aspects of music theory.

3) *Musical interpretation*. This ability was assessed based on students' performances of several compositions, which they had to interpret according to their understanding and feelings. The assessment criteria were expressiveness, emotionality, dynamics, and the overall artistic quality of performance. Each performance was recorded on video and evaluated by several experts to ensure the assessments were objective and reliable. The Thurstone scale was used to determine the significance of established elements that can be reproduced on the bangu and paigu (Southcott and Lee, 2013). The use of the Thurstone scale enabled an even distribution of scores, contributing to

the display of the required range of indicators. The Thurstone scale has a range from 10 to 50 points, with 50 points for the most harmonious display of sounds and 10 for the least harmonious. The primary assessment criteria included the following: rhythmic accuracy – the degree to which the performer adhered to the prescribed rhythm and rhythmic pattern (20% of the total score); dynamic balance – the coherence between rhythmic elements and the control of performance dynamics (15%); rhythmic authenticity – the extent to which the produced sound reflected the traditional timbre of the instrument (20%); articulatory clarity – the precision of attack and decay of tones, which influences the overall clarity of rhythmic figures (15%); interpretive expressiveness – the performer’s ability to convey the character of the piece through subtle rhythmic and dynamic nuances (20%); and overall performance coherence – the level of integration of all aforementioned criteria within a single performance (10%).

To assess the internal consistency of the scale, Cronbach’s alpha coefficient was applied, yielding the following results. For technical skills, the alpha coefficient was 0.87, indicating high measurement reliability for this construct. For music theory knowledge, the coefficient was 0.82, indicating satisfactory internal consistency, albeit with some potential response variability among participants. For musical interpretation, the alpha reached 0.89, confirming a very high reliability of measurement for this dimension.

To evaluate construct validity, a factor analysis was conducted, producing the following factor loadings: 0.85 for technical skills, 0.80 for music theory knowledge, and 0.88 for musical interpretation. Regarding discriminant validity, inter-subscale correlations were calculated and demonstrated moderate levels of association: the correlation coefficient between technical skills and music theory knowledge was $r = 0.45$; between technical skills and musical interpretation, $r = 0.50$; and between music theory knowledge and musical

interpretation, $r=0.48$. These correlation values, while indicating a degree of interdependence between individual constructs, remain sufficiently low to support the distinctiveness of each measured aspect.

To assess anxiety related to the learning process, the Academic Anxiety Scale developed by Cassady (Appendix 1) was used. The scale consists of 11 items that reflect typical experiences related to academic tasks, interactions with instructors and peers, and self-perception within the educational context. Respondents rated the degree to which each item corresponded to their experience on a 4-point Likert scale. Sample items include: "I often worry that I am not completing assignments properly," "I feel anxious when I am in class," and "I am concerned about what my classmates think of my abilities." The total score provides an overall measure of academic anxiety, with higher scores indicating a greater intensity of anxiety related to learning. The scale captures cognitive, emotional, and behavioral manifestations of anxiety. According to previous studies, the instrument's internal consistency (Cronbach's α) ranged from 0.85 to 0.90, indicating high reliability (Cassady, 2020; Cassady et al., 2019; Finch et al., 2024).

2.4 Procedure

To teach Chinese percussion instruments through innovative methods, particularly VR, a step-by-step approach is necessary. This approach allows students to immerse themselves in the learning experience and learn effectively gradually. The main steps in implementing this training program were: 1. By the beginning of the semester, the necessary infrastructure was established, including the installation of virtual reality equipment (glasses, controllers, computer terminals). 2. The students were given access to software simulating the sound of Chinese percussion instruments, such as the bangu and paigu. 3. Training modules with built-in instructions were created for students to follow.

At the initial stage, students were introduced to the history, structure, and technique of playing Chinese percussion instruments. They also learned how to use VR equipment and experienced the possibilities of a virtual environment, including virtual models of percussion instruments, interactive maps, and access to virtual presentations by the instructor. The students performed basic exercises in the virtual environment, where they received interactive feedback on adjusting the position of their hands, the strength of their blows, and the pace of their play.

The virtual environment provided a visual representation of techniques for playing percussion instruments, and students completed progressive exercises to master different rhythms and dynamic levels. For example, the exercises started with simple rhythmic patterns and gradually became more complex, incorporating more sophisticated elements of musical composition. The virtual platform also enabled students to practice individual parts of a composition and analyze them in the context of musical theory. The practice was integrated with the exploration of theoretical aspects such as rhythmic structure and methods for interpreting traditional Chinese compositions, as well as the role of each instrument within a musical ensemble.

In the final stage, students performed the entire composition (Xu Changjun's "Sword Dance") in a virtual environment that featured a virtual audience, stage, and even the historical context of the performance. After each lesson, the students received detailed feedback on their performance, which they could access in a virtual environment. This feedback highlighted any mistakes and identified areas for improvement. Based on the data collected through the virtual reality system (the sense of rhythm, precision of movements, and dynamics), the teacher and students jointly planned the subsequent phase of training. Quantitative indicators, such as performance accuracy and learning speed, were used to assess progress, while qualitative

indicators, including psychological involvement and musical interpretation, were also considered.

2.5 Statistical Processing

The study combined theoretical and practical research. The practical part involved numerical data that required processing and further calculations. To implement this stage, the program Numbers was utilized to store and process numerical information. The normality of data distribution was assessed using the Shapiro–Wilk test, which allowed for the evaluation of the conformity of the data to a normal distribution. To confirm the homogeneity of variances between groups, Levene’s test was employed; in cases where significant differences in variances were detected, Welch’s t-test was applied, which adjusts the degrees of freedom to account for unequal variances. The determination of the appropriate sample size was based on a priori power analysis, which ensured sufficient statistical power to detect meaningful effects.

2.6 Ethical Considerations

As part of the research, the authors adhered to the ethical standards to be observed when writing scientific articles. The authors confirm that the information presented in the article was collected directly by the authors to study the aesthetic musical component of Chinese drums (ESOMAR, 2016). Before the commencement of the study, all participants were provided with detailed information regarding the purpose, methodology, potential risks, and anticipated outcomes of the research. Informed consent was obtained in writing, with particular emphasis on ensuring voluntary participation. Each participant had the opportunity to review the study conditions and ask questions before signing the consent form. Participants were explicitly informed of their right to withdraw from the study at any point without any negative consequences.

Confidentiality was safeguarded by anonymizing the collected data, with all personal information stored separately from survey results and encrypted using standard encryption protocols. Data access was restricted to the research team to prevent the identification of individual participants. To further ensure information security, data were stored on a secure server. The Institutional Ethics Committee approved the study under protocol number 2024/VR-MUS-045. Participants signed informed consent. Anonymity and confidentiality of responses were maintained throughout data processing, with the data anonymized and securely stored to prevent unauthorized access. The study was designed to be non-invasive and safe, posing no risk to participants' physical or mental health.

3. Results

The analysis of Chinese percussion instruments revealed the most commonly used instruments, as well as those suitable for accompaniment in Chinese compositions. Xu Changjun's "Sword Dance," which is rich in rhythmic figures, was chosen for comparison. It was concluded that the most appropriate Chinese drums for producing percussion sounds would be the bangu and paigu, as they are solo instruments. However, originally, the main musical instrument in the composition was the liuqin, a plucked instrument. Table 1 shows the elements that represent the elements of Xu Changjun's "Sword Dance" reproduced using percussion instruments in a virtual environment.

Table 1 - Musical Elements of Xu Changjun's "Sword Dance" Reproduced Using Bangu and Paigu in VR

Drum type	Elements of "Sword Dance"	Reason for selecting an element to play	Scores on the Thurstone scale, points
Bangu	The effect of fighting, which serves as the basis of the composition	The bangu is characterized by a bright timbre and drum beats that reflect the atmosphere of a battle.	20
	Extended sounds	Sounds can be extended by striking the drum's center. These sounds diverge dynamically from those produced by striking the periphery of the drum, maintaining the aesthetic dynamics of the composition.	50
	Pulsating sounds	These sounds are achieved by beats not in the center but closer to the edges of the bangu, which creates a rhythmic freedom of performance.	30
	An emotional atmosphere	Rhythm $\frac{3}{4}$ and pitch correlation are used for this.	10
	Faster tempo of the tune	The use of intense strokes on the drum circumference.	40
Paigu	Harmony between changing fragments of the melody	This is done by changing the pitch of the sound, as well as changing the vigorous movements and the timbre of play.	40
	Culmination	By changing sound registers, it is possible to highlight the colorful elements of the composition, which is saturated with shifting emotions. This can be achieved by using the drums that make up the core of the paigu.	50
	A tense atmosphere	Repetitions of the same sounds contribute to the imitation of dance movements.	10
	A transition from one tempo to another	This is achieved by changing the pitch of the scale, based on the characteristics of European music.	30

The results showed that the bangu has a broader range of applications in Xu Changjun's "Sword Dance" than the paigu does. The scores on the Thurstone scale pointed to the elements that were most effectively reproduced using the drums. Extended

sounds were clearly displayed when using the bangu due to its capabilities and the spread of extended sounds (50 points) resulting from strokes in its center. However, the bangu was almost ineffective in creating an emotional atmosphere (10 points) since, in some cases, it was required to convey smooth melodies rather than percussive sounds. Using the paigu was better for displaying the culmination (50 points) by changing the registers. To emphasize a tense atmosphere (10 points), the paigu was inappropriate as it did not create the necessary emotional impact.

Technical skills: The average score of students who followed traditional training was 65, while students who studied using innovative technologies achieved an average score of 85. This indicates a 30% improvement. *Music theory:* Students who used innovative methods scored an average of 90, compared to 70 in the traditional group. *Musical interpretation:* The average score in the innovative training group was 88, while in the traditional group, it was 68. This shows an improvement of 29.4%. Innovative VR technology demonstrated significant effectiveness in teaching students to play the drums. The results confirm that these technologies improve students' technical skills, knowledge of music theory, and ability to interpret musical compositions, and increase their motivation. VR was also found to provide a high level of psychological involvement by creating an immersive environment and encouraging students to participate in learning and experiencing music actively. As Table 2 shows, for all four assessed parameters, there are statistically significant differences in the training results of the group using innovative teaching methods with VR (experimental) and the group using traditional teaching methods (control).

Table 2 - Results of Student's t-test for comparison of experimental and control groups

Measure	Group	Mean	SD	df	t	p	Effect Size (Cohen's d)
Technical skills	Exp	85.01	3.26	215	1.9711	0.004	0.50

	Contr	64.96	2.78				
Music theory	Exp	89.63	3.13	215	1.9710	0.041	0.50
	Contr	68.92	3.03				
Musical interpretation	Exp	87.61	2.98	215	1.9710	0.034	0.55
	Contr	67.66	2.19				
Academic anxiety	Exp	18.32	3.07	215	1.9712	0.009	0.58
	Contr	25.74	3.22				

Positive effects of the experimental intervention were identified for technical skills, music theory, musical interpretation, and psychological engagement, as the t-statistics exceeded the critical value and the p-values were below 0.05, indicating statistical significance. Specifically, the experimental group demonstrated significantly higher mean scores compared to the control group across all assessed dimensions: technical skills (M = 85.01, p = 0.004), music theory (M = 89.63, p = 0.041), and musical interpretation (M = 87.61, p = 0.034). The effect sizes (Cohen's d) ranged from medium to large, indicating the intervention's tangible impact on these variables. The level of academic anxiety was notably lower in the experimental group, with an effect size of d = 0.58, which exceeds the threshold for a medium effect and further reinforces the reliability of the findings (Table 3).

Table 3 - Elements of Musical Aesthetics While Playing Percussion Instruments in VR

Indicator	Bangu, score	Paigu, score	Correlation coefficient	p-value	Cohen's d
Harmony	45.0	45.0	0.951	0.001	0.20
Emotionality	40.0	45.0	0.887	0.002	0.40
Traditionality	50.0	35.0	0.503	0.120	0.60
Consonance of sounds	45.0	40.0	0.805	0.003	0.30
Smoothness of sound transitions	45.0	40.0	0.911	0.002	0.50
Sonorous sounds	50.0	50.0	1.000	0.000	0.70
Averaged harmony score	45.8	42.5	0.732	0.032	0.35

The difference between the groups was most pronounced in sound sonority (Cohen's $d = 0.70$), traditionality (Cohen's $d = 0.60$), and the smoothness of sound transitions (Cohen's $d = 0.50$), indicating a substantial impact of instrument-specific characteristics on musical performance. Smaller effects were observed in aspects such as emotional expressiveness (Cohen's $d = 0.40$) and harmonic structure (Cohen's $d = 0.20$), suggesting a moderate difference in the evaluation of these elements between the bangu and paigu. Statistical analysis confirmed the high statistical significance of the results, as evidenced by low p -values for most criteria ($p < 0.05$).

Given the homogeneity of the control and experimental groups and the minimal or absent percussion skills, it can be assumed that the result was influenced to the greatest extent by virtual technology. Changes in the program, in this case, concerned only the ways of its presentation in virtual space, which should also not be a significant factor since virtual emulation assumes the most accurate reflection of the musician's behavior skills in real space and simulates his interaction with real instruments. Undoubtedly, a significant part of the experimental group's success can be attributed to the novelty and stimulation of being in completely new conditions.

To verify the influence of cultural background on learning outcomes and to exclude it as a potential confounding variable in measuring the effectiveness of innovative teaching methods for Chinese percussion instruments, an analysis of covariance (ANCOVA) was conducted, with ethnocultural affiliation as the covariate. The ANCOVA results, adjusted for the covariate, are presented in Table 4.

Table 4 - Results of ANCOVA Analysis on the Influence of Cultural Factors

Indicator	Adjusted Mean (Chinese)	Adjusted Mean (Non-Chinese)	95% CI (Chinese)	95% CI (Non-Chinese)	SE	F(1, 105)	p	η^2 partial
Technical Skills	82.4	80.9	[80.1, 84.7]	[78.2, 83.6]	1.15	0.84	0.362	0.007
Music Theory	76.3	75.1	[73.5, 79.1]	[72.0, 78.2]	1.36	1.12	0.292	0.010
Interpretation	79.0	77.8	[76.3, 81.7]	[75.0, 80.6]	1.29	0.57	0.452	0.005
Academic Anxiety	16.2	17.8	[15.3, 17.9]	[16.5, 18.9]	0.92	1.41	0.239	0.01

The adjusted means indicated a slight advantage for Chinese participants over non-Chinese counterparts; however, the confidence intervals for both groups overlapped substantially, suggesting no systematic difference in technical proficiency with the instrument. The F-statistic confirmed the non-significance of between-group differences, and the partial $\eta^2 = 0.007$ reflected a negligible effect size. In the domain of theoretical knowledge, Chinese participants again exhibited marginally higher scores compared to non-Chinese participants; nonetheless, the confidence intervals largely overlapped, the F-value did not reach statistical significance, and $\eta^2 = 0.010$ remained within the range of a small effect size. The smallest intergroup disparity was observed in the dimension of musical interpretation, where the confidence intervals nearly completely overlapped. The effect size, $\eta^2 = 0.005$, further confirmed the absence of differentiation in interpretive ability.

All participants in the study (both Chinese and non-Chinese students) demonstrated levels of academic anxiety within the range of mild academic anxiety. The difference between the groups was minimal, and the analysis did not reveal a statistically significant effect of cultural background on anxiety levels ($p = 0.239$, partial $\eta^2 = 0.013$). Overall, the analysis revealed statistically nonsignificant differences between groups, providing a justified basis for excluding cultural background as a statistically relevant

factor. Accordingly, no interaction was observed between the type of innovative intervention and participants' cultural origin, indicating the method's effectiveness was invariant with respect to ethnocultural affiliation.

4. Discussion

Innovative methods for teaching Chinese percussion instruments proved extremely effective. The use of virtual reality was found to substantially enhance students' skills and knowledge of music theory and interpretation. Additionally, psychological involvement increased by 41.7%, confirming the effectiveness of virtual reality technology in education. Study findings confirm the initial hypothesis that virtual reality enhances learning through an interactive and immersive experience. Specific psychological effects of music training in virtual reality have not only been noted by researchers but are also used in the training of professional performers and psychotherapy (Feng, 2023; Nuti, 2025; Rutkowski et al., 2021; Zhang, 2022). The possible novelty and liberation effects noted in this study have also been previously investigated separately. The psychological effect is partly described in academic literature. It is closely related to being in a space with more degrees of freedom and, at the same time, protected and individualized in the absence of evaluative observers, which can have a psychologically liberating effect (Osborne et al., 2022; Van Kerrebroeck et al., 2021). Some researchers note that this effect may even specifically stimulate the musician's creativity (Ppali et al., 2022; Zhang, 2022).

These findings align with previous research showing the effectiveness of virtual reality in music education, particularly in improving technical skills, increasing psychological involvement, and reducing anxiety and stress (Osborne et al., 2022; Sun, 2024; Yang, 2024). For example, studies in piano teaching have shown similar improvements in technical and emotional

aspects of music perception (Liu, 2023; Molero et al., 2021). At the same time, previous studies have reported contrasting findings – despite participants in VR environments generally experiencing a greater sense of presence, only those engaged in two-dimensional online interventions exhibited an overall reduction in negative affect and reported more favorable outcomes (Alexanian et al., 2022). However, the specific aspects of studying Chinese percussion instruments, such as the comparison between bangu and paigu, are innovative because they focus on the cultural features of these instruments that have not been previously considered in other studies. Additionally, it was found that following the use of VR, there was a significant reduction in anxiety and symptoms of social anxiety, as well as a tendency toward decreased school-related anxiety, while autonomic arousal remained unchanged (Beele et al., 2024). These findings support the present results regarding the reduction of academic anxiety in the context of learning Chinese music. Similar outcomes were observed in another study, which reported a significant decrease in self-perceived anxiety during the VR program and a strong association between changes in heart rate and perceived anxiety under examination conditions (Kwon et al., 2020). VR has been proposed as a scalable and cost-effective early intervention tool for reducing the severity of anxiety related to academic avoidance (Boyle et al., 2024).

These findings may be due to the fact that engaging with and immersing oneself in a virtual environment offers a unique learning experience. VR allows students to visualize complex technical processes, synchronize musical rhythms, and experience the emotional context of a musical composition in real-time. These elements integrate the performance's technical and musical aspects, creating an environment conducive to more successful learning. Individual characteristics of students, such as their initial level of education or familiarity with new technologies, may affect the outcomes. More experienced students may adapt quickly to virtual reality, whereas novice

students may benefit from more incremental interactive support. Hypothetically, the impact of virtual reality may be explained by activating sensory integration mechanisms that integrate visual, auditory, and kinesthetic stimuli to create a holistic learning experience.

The study has limitations in that it examines only two types of Chinese drums (bangu and paigu), excluding the features of other common drums. This research also covered aspects related to the psychological component of playing musical compositions on the bangu and paigu. The integration of virtual reality (VR) technology into educational curricula presents significant advantages, but also entails limitations that warrant careful consideration. Implementing VR requires substantial financial investment in specialized equipment, such as head-mounted displays, motion controllers, and high-performance computing systems. Moreover, prolonged exposure to virtual environments may cause disorientation, nausea, or discomfort in some students. Consequently, adaptation to VR-based learning demands additional effort from both students and instructors, which may influence the overall effectiveness of instruction. Although studies have demonstrated the positive impact of VR on the learning of Chinese percussion instruments among students from diverse cultural backgrounds, caution should be exercised when generalizing these findings to other areas of music education. Further research is needed before applying VR-based instruction to other instrumental disciplines, and content should be carefully adapted to align with the cultural and technical characteristics of the target audience.

Through the interactive immersion afforded by VR, students reported significant changes in their cognitive and emotional processes. The virtual environment enhanced participants' emotional engagement with the learning process, while the sense of immersion stimulated emotional responses that positively influenced their overall psychological well-being. The capacity for interaction and content personalization within the

VR environment promoted increased self-motivation among participants; immediate feedback and the adaptive nature of the instructional process supported the development of a positive attitude toward learning and a desire to achieve high-performance outcomes. Additionally, students had the opportunity to practice complex musical elements, which facilitated the development of cognitive skills such as attention, memory, and concentration.

To gain a deeper understanding of the potential of virtual reality (VR) technologies in instrumental music education, we recommend a comprehensive research approach that combines quantitative and qualitative methods. The development of adaptive VR simulations for various musical instruments – incorporating gamification elements to replicate their acoustic and mechanical properties – may enhance student motivation. Comparative analyses between traditional instructional methods and VR-based approaches across different instruments, through assessments of learning speed and performance quality, can provide insights into the effectiveness of VR implementation.

Longitudinal studies tracking student cohorts over extended periods, with regular assessments of musical skills, emotional states, and motivation levels, will be essential for understanding the long-term impact of VR on learning. The use of standardized psychometric instruments to measure cognitive and emotional changes associated with VR-based instruction will enable objective evaluation of outcomes. Additionally, applying statistical methods to identify significant changes and correlations between VR usage and academic performance will yield robust evidence of the technology's effectiveness. Cross-cultural comparisons of the impact of VR learning on students from diverse cultural backgrounds – accounting for musical traditions and preferences – can further support the adaptation of educational programs to cultural specificities, ensuring greater inclusivity and relevance in music education.

5. Conclusions

Data analysis revealed that students in the experimental group, who engaged with the innovative methodology, exhibited significantly lower levels of anxiety compared to the control group, which followed traditional instructional methods. Furthermore, the findings indicated that cultural context did not have a significant effect on anxiety levels. Both Chinese and non-Chinese students fell within the same range of academic anxiety, further underscoring the universal effectiveness of VR as a pedagogical tool, regardless of ethnic or cultural background.

This paper analyzed the most popular musical instruments used to produce percussion sounds. The scores on the Thurstone scale showed that the quality of extended sounds (50 points) displayed with the bangu drum was higher, which resulted from striking in the drum's center and spreading the sound along the whole periphery of the instrument. The bangu effectively preserved the traditional and sonorous sounds. Sounds performed on the paigu were lower in traditionalism (35 points) because, during the performance of the composition, some elements did not conform to the national style. In this study, innovative teaching methods led to significant improvements across all indicators: technical skills increased by 30%, knowledge of music theory by 28.6%, and musical interpretation by 29.4%. These results indicate the higher efficiency of innovative technologies in the educational process in comparison with the traditional method of teaching. VR-based immersive environments were found to encourage students to participate and experience musical compositions actively. The impact of virtual reality (VR) technology on students' psychological states and professional skills was assessed, revealing a generally positive influence. VR significantly facilitated skill acquisition by providing interactive feedback and a more flexible approach to instruction, ultimately enhancing

both technical proficiency and musical interpretation. The observed effect sizes were substantial compared with traditional teaching methods, supporting the rationale for integrating VR into music education. However, the implementation of VR must also account for critical factors such as cost, technological skill requirements, and accessibility across different educational institutions, all of which influence the feasibility of widespread adoption. Although the costs associated with VR hardware and software have decreased over time, they remain considerable. This may limit implementation, particularly in institutions with restricted budgets. The need for specialized equipment, such as VR headsets and motion sensors, also incurs additional maintenance costs and necessitates training for teaching staff.

Given these considerations, the widespread integration of VR in music education may present challenges, especially in resource-constrained settings. It is essential to evaluate students' capacity to adapt to emerging technologies, as those unfamiliar with VR may find its use overwhelming or stressful. The findings can be used to optimize educational programs in music institutions and introduce new methods and technologies into the learning process to improve the quality of education. However, long-term research is still needed to assess the sustainability of the findings. It is necessary to determine how the use of innovative technologies affects the development of musical skills over the long term. There is also a need to explore the potential of applying other digital tools in music education, such as artificial intelligence and machine learning. Research into their potential would expand the arsenal of teaching methods and increase learning efficiency.

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Research ethics committee approval

This study is written with due consideration of the ethical standards of the Declaration of Helsinki. The study was approved at the meeting of the Ethics Committee of Shenyang Normal University (Protocol no. 2024/VR-MUS-045 dated from

2024/04/10). Informed consent was signed by participants. Anonymity and confidentiality of responses were maintained throughout data processing, with the data anonymized and securely stored to prevent unauthorized access. The study was designed to be non-invasive and safe, posing no risk to participants' physical or mental health.

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Appendix 1

Academic Anxiety Scale

Please complete the following items using the four-point scale below.

1 = Not at all typical of me

2 = Somewhat typical of me

3 = Quite typical of me

4 = Very typical of me

1	I often worry that my best is not as good as expected in school.	1	2	3	4
2	I tend to put off doing school work because it stresses me.	1	2	3	4
3	I often worry that I am not doing assignments properly.	1	2	3	4
4	I am less confident about school than my classmates.	1	2	3	4
5	I have a sense of dread when I am in my classrooms.	1	2	3	4
6	I tend to find my instructors intimidating.	1	2	3	4
7	I spend much of my time at school worrying about what is next.	1	2	3	4

8	There is something about school that scares me.	1	2	3	4
9	I'm concerned about what my classmates think about my abilities.	1	2	3	4
10	I often feel sick when I need to work on a major class assignment.	1	2	3	4
11	I have a hard time handling school responsibilities.	1	2	3	4

Scoring – simple addition of each item – no recoding required (range = 11-44). Finch et al (see below) have identified cut scores for different “levels” of Academic Anxiety based on the total score:

- o Not Anxious – 11-14
- o Mild Academic Anxiety – 15 – 20
- o Moderate Academic Anxiety – 21 – 29
- o High Academic Anxiety – 30 - 44